

## Advanced Composite Materials for Precision Segmented Reflectors

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The objective of the Langley Research Center (LaRC) program in the NASA Precision Segmented Reflector (PSR) Project is to develop new composite material concepts for highly stable and durable reflectors with precision surfaces. The LaRC Program is focusing on alternate material concepts such as the development of new low coefficient of thermal expansion (CTE) resins as matrices for graphite fiber reinforced composites, quartz fiber reinforced epoxies, and graphite reinforced glass. Low residual stress fabrication methods will be developed. When coupon specimens of these new material concepts have demonstrated the required surface accuracies and resistance to thermal distortion and microcracking, reflector panels will be fabricated and tested in simulated space environments. An important part of the LaRC program is analytical modeling of environmental stability of these new composite materials concepts through constitutive equation development, modeling of microdamage in the composite matrix, and prediction of long-term stability (including viscoelastic behavior). These analyses include both closed form and finite element solutions at the micro and macro levels.

Examples of the use of this modeling capability for prediction of material properties is shown in FIGURES 1 and 2. One goal of new materials development for PSR is to reduce through-the-thickness (t-t-t) CTE of polymer matrix composites to minimize distortions in composite panel face sheets. FIGURE 1 shows that a reduction of CTE by an order of magnitude (CTE  $E_p/10$ ) is a good goal for low CTE epoxy development. It also shows that the modulus of the graphite reinforcement fiber does not affect t-t-t CTE. Also shown in FIGURE 1 is the low t-t-t CTE of Gr/glass which makes it a candidate material for PSR applications.

FIGURE 2 shows further use of the modeling capability to predict maximum thermally induced matrix stresses at the micro level for the composite materials of interest. Both the conventional Gr/Ep and the Quartz/epoxy have residual epoxy tensile and compressive stresses higher than 10 ksi, with a maximum  $\Delta T$  (from stress-free temperature to service temperature) of  $-450^\circ\text{F}$ . The Gr/low-CTE epoxy residual stresses are below 1 ksi. Gr/glass composites, with  $\Delta T$ 's in the range of  $-900$  to  $-1100^\circ\text{F}$ , develop residual glass compressive stresses approaching 40 ksi.

These analyses have indicated the high payoff directions for alternate materials research for PSR: Low CTE resin matrix composite development, minimization of residual stresses in conventional epoxy matrices reinforced with graphite or quartz fibers, and development of glass matrix composites with low fabrication temperature and/or thermal treatments to minimize stress in Gr/Gl.

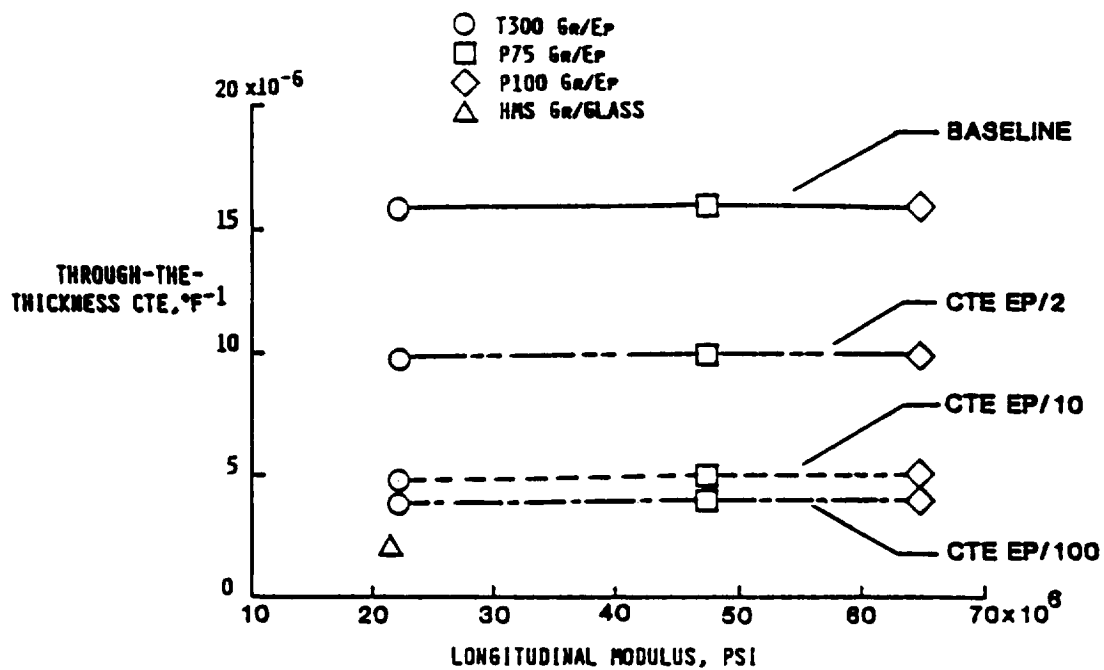


FIGURE 1. Effect of Matrix CTE on Lamina Properties

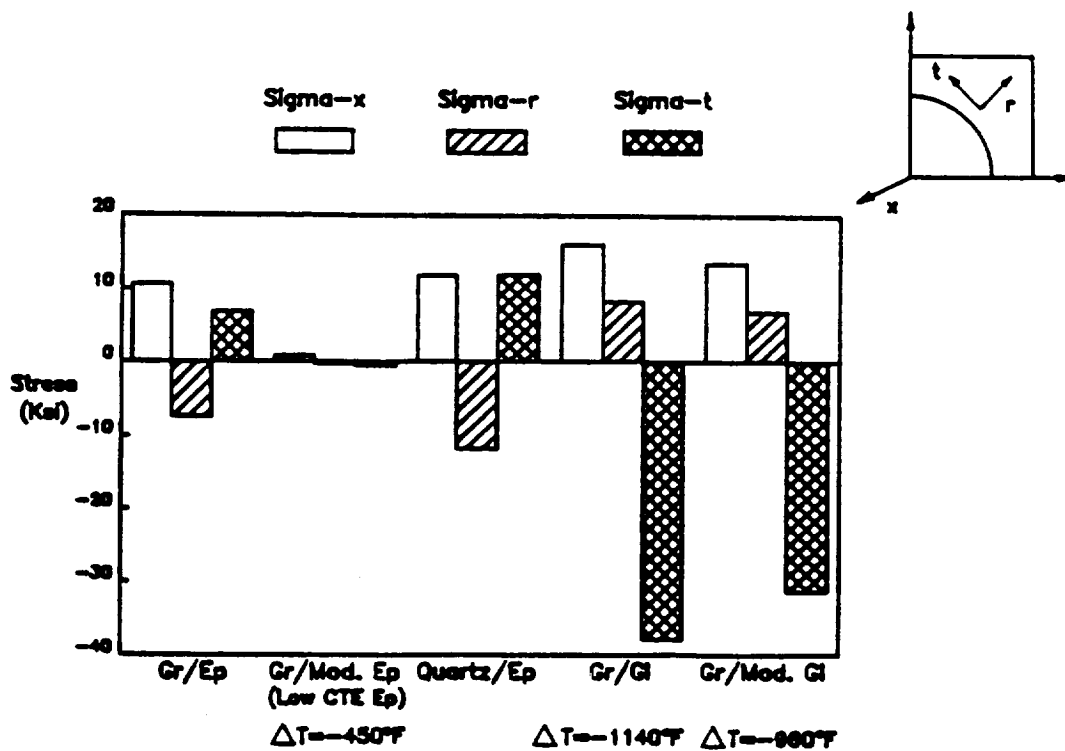


FIGURE 2. Maximum Thermally Induced Matrix Stresses in a Single Unidirectional Layer